A PRELIMINARY REPORT ON THE TORNADOES OF MARCH 21-22, 1952

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INTRODUCTION

On March 21, 1952, at 1430 CST, Dierks, Ark., reported a tornado which, it turned out, was the precursor of an intense outbreak of a series of tornadoes, beginning 3 hours later over northeastern Arkansas and western Tennessee and, during the following 23 hours, over portions of Alabama, Kentucky, Louisiana, and Mississippi. Arkansas was hardest hit as indicated by estimates of property damage reaching 25 million dollars. The death toll for the 6 States was placed at about 200 and the injured at over 1,000 people.

The greatest concentration of violent storms occurred in the warm, moist, maritime tropical air just to the south of a quasi-stationary front over portions of Arkansas and Tennessee and in association with an easterly moving instability line. In addition, scattered tornadoes in 4 States were associated with the passage of a continental Polar cold front which followed the instability line.

The purpose of this article is to discuss the conditions related to this situation.

SUMMARY OF TORNADO ACTIVITY

The surface charts (figs. 1, 2, 6, and 7) depict the surface conditions during the tornado period and at times when upper air soundings were available. On figure 1 for 9:30 a. m. CST (1530 GMT) areas or points where tornadoes were reported are shown by dots. The dot in southwestern Arkansas, at Dierks, represents the first reported storm

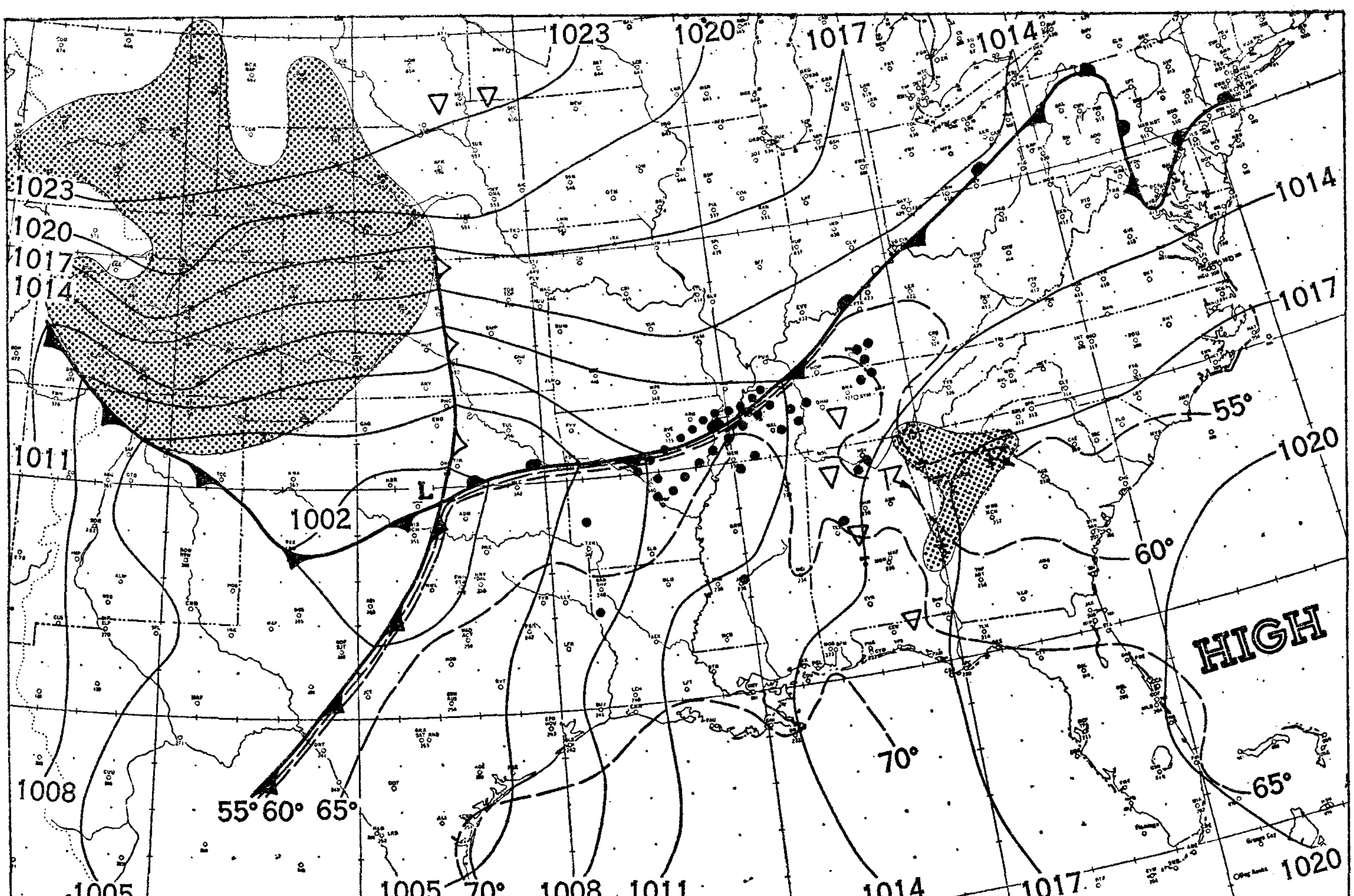

FIGURE 1.—Surface chart, 1530 GMT, March 21, 1952. Shaded areas, shower and thunderstorm symbols indicate precipitation in progress. Dots or dotted areas indicate approximate location of reported tornadoes. Isopleths (dashed lines) of dew point are at intervals of 5° F.

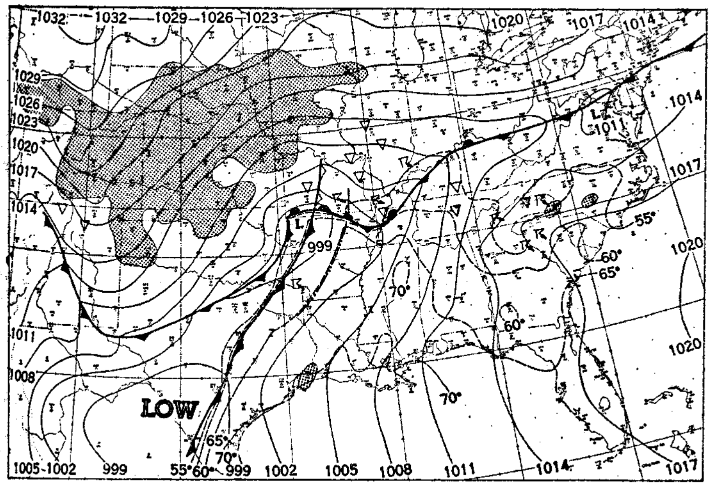

FIGURE 2.—Surface chart, 0030 GMT, March 22, 1952.

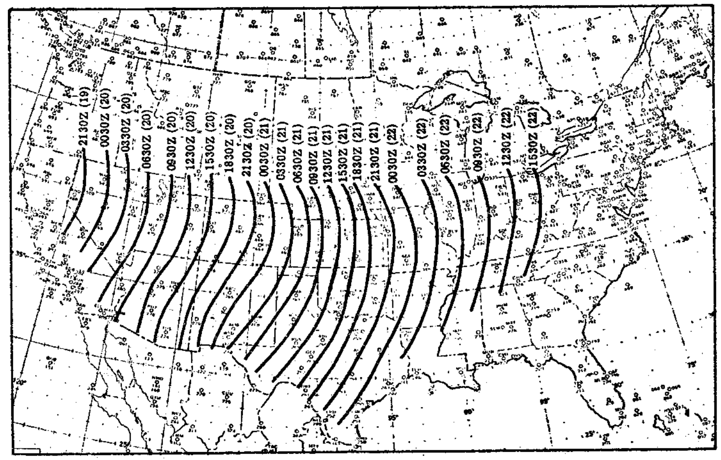

FIGURE 4.—Position of the maritime Polar (Pacific) front at 3-hourly intervals, March 19–22, 1952. Time in GMT (Z).

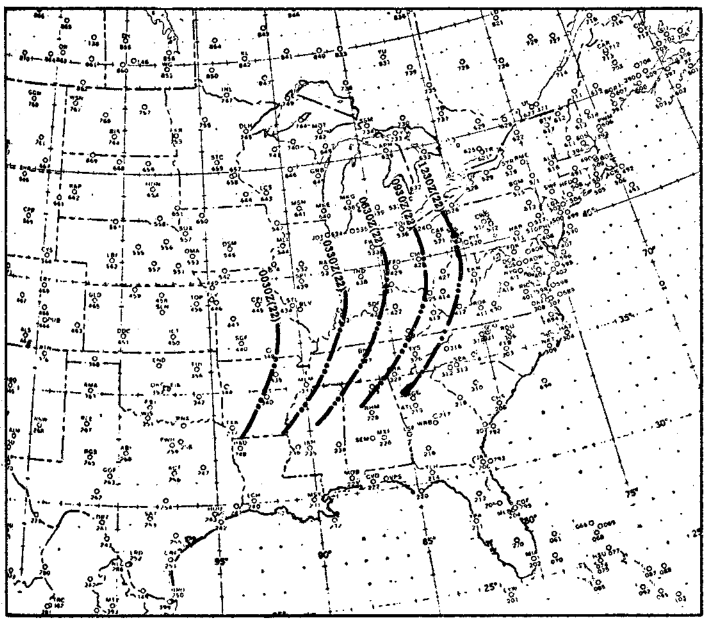

FIGURE 3.—Position of the instability line at 3-hourly intervals, March 22, 1952. Time in GMT (Z).

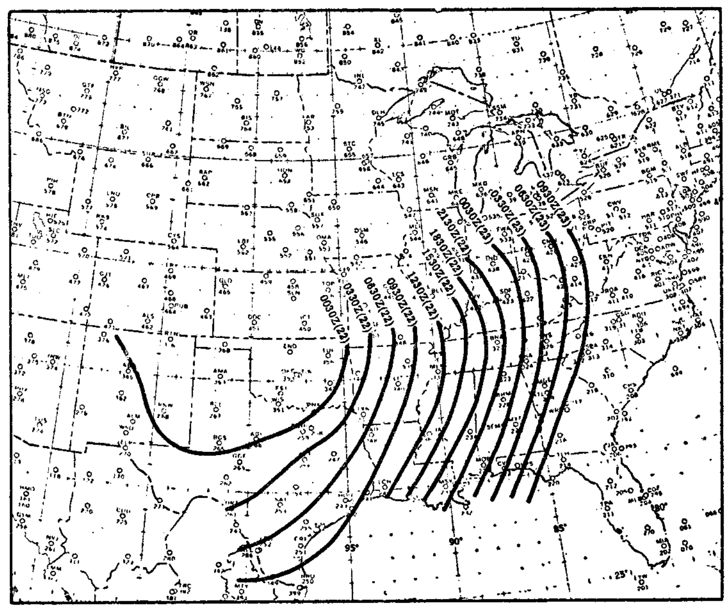

FIGURE 5.—Position of the continental Polar front at 3-hourly intervals, March 19–22, 1952. Time in GMT (Z).

presumably associated with the instability line which was just forming. Tornadoes within the oblong area from central Arkansas northeastward to Tennessee were associated with the passage of the instability line as were tornadoes in 3 other areas, one southeast of Memphis, another northeast of Jackson, Tenn., and one storm 50 miles northeast of Bowling Green, Ky. The dots, or areas, in Louisiana, Mississippi, Alabama, the area northeast-to-east of Bowling Green, Ky., and the small region northeast of Nashville, Tenn., represent locations of tornadoes associated with the continental Polar cold front.

Approximately 5 hours before the first tornado, the major low center was near Ft. Sill, Okla., as shown by figure 1. On this map the distribution of surface dew point temperatures is outlined, the axis extending northward along the Mississippi River toward Memphis where it bends northeastward between the stationary front and the southern Appalachians.

With the passage of the Low toward southwestern Missouri, the tightening of the pressure gradient, cooling behind the instability line, and solar heating during the afternoon, the weather became considerably more active as shown by figure 2, which is for nine hours after the time of figure 1. By this time, the instability line was well developed and attended by severe thunderstorm activity, and north-northeast of Little Rock, Ark., tornadoes were in progress.

The gradient winds were 30–35 m. p. h. from the south to south-southwest over Arkansas and Louisiana, and were from the south-southeast over Mississippi. These areas

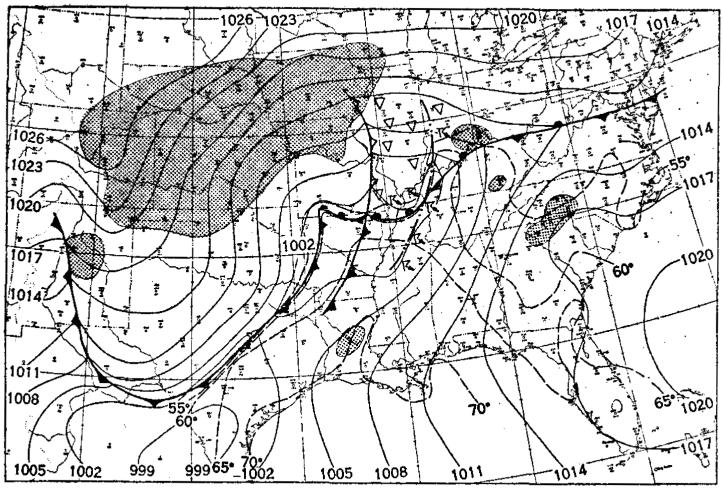

FIGURE 6.—Surface chart, 0330 GMT, March 22, 1952.

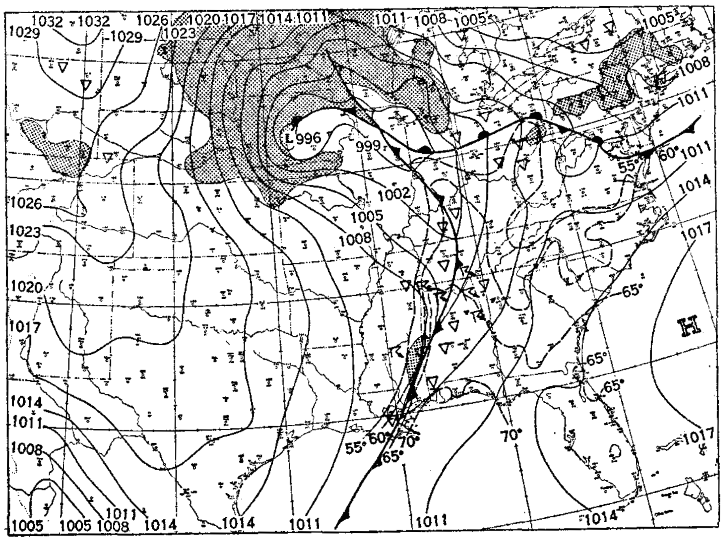

FIGURE 7.—Surface chart, 2130 GMT, March 22, 1952.

coincide with the area covered by the 65° dew point line (fig. 2). Together, these two facts reveal a strong surface transport of moist air toward the low center. One hour after this map, tornadoes were reported in the region of northeastern Arkansas close to the Mississippi River, generally west and northwest of Memphis. The 3-hourly histories of the instability line and of two cold fronts of the system are presented by figures 3, 4, and 5 respectively. The first cold front (fig. 4) separating mT and mP (Pacific) air, and the second (fig. 5) lying between the mP and colder cP air.

The surface synoptic conditions just after the tornadoes began in western Tennessee, the second hardest hit of the 6 States, is illustrated by figure 6, for 9:30 p. m. CST (0330 GMT). The first reports of tornadoes in Tennessee came from the general region of Dyersburg at approximately 8:30 p. m. CST (0230 GMT of the 22d), followed by a new group of reports from the areas southeast of Memphis, northeast of Jackson, and about 50 miles northeast of Bowling Green, Ky., (fig. 1). Reports from the latter areas fixed the time of occurrences as approximately 10 p. m. to midnight CST (0400 to 0600 GMT of the 22d) which coincides with the passage of the instability line.

Curiously, at least one tornado, in the vicinity of Bruceville, Tenn. (about 10 miles south of Dyersburg), occurred near 5:30 p. m. CST (2330 GMT) well ahead of the main outbreak in that area, about the same time as the first appearance of the major outbreak in the vicinity of Little Rock, Ark. It would seem that this one storm, so far ahead of the main band of tornadoes, was an isolated affair related to some comparatively local influence. Certainly, there was a high degree of conditional instability at the time, as will be discussed later.

All reported tornadoes on the 22d, beginning with the early morning hours (CST), were associated with the passage of the continental Polar cold front. Mansfield, La., about 12 miles south-southwest of Shreveport, reported one around 2 a. m. CST (0800 GMT) on the 22d. Seven hours later Madison and Tougaloo, Miss. (about 12 and 20 miles respectively from Jackson) reported what appears to have been one tornado. The vicinity of Tuscaloosa, Ala., was struck at approximately 2:15 p. m. CST (2015 GMT), and near the same time, one was reported 50 miles southwest of Huntsville, Ala. Around 3:30 p. m. CST (2130 GMT) one occurred at Portland, Tenn. (northeast of Nashville), and near 4 p. m. CST (2200 GMT) two others were reported within 25 miles to the south and southeast of Huntsville, Ala. Figure 7, for 3:30 p. m. CST (2130 GMT), represents the surface synoptic conditions when tornadoes were occurring in Alabama.

THE VERTICAL STRUCTURE

The knowledge of the vertical structure of temperature, moisture, and wind is of considerable importance in tornado studies. Unfortunately in this case, a detailed study of wind structure was not possible because of the absence of pilot balloon observations in the zone of severe weather. However, the regular RAWIN observations at 0300 GMT, on March 22, present enough information to be useful in this case study. Figures 8, 9, and 10 in connection with the corresponding surface map (fig. 6) are intended to convey the vertical picture at 0300 GMT, close to the time of the maximum tornado activity. The 850-mb. chart (fig. 8) suggests the vertical extent of the moist tongue as shown, for example, by the area enclosed within the 10° C. dew point line. As on the surface chart (fig. 6), there is also strong northward advection of moist air at the 850-

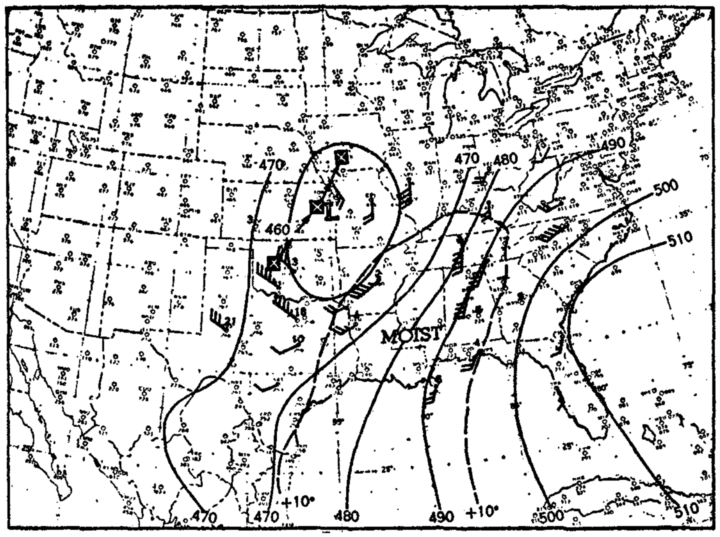

FIGURE 8.—850-mb. chart, 0300 GMT, March 22, 1952. Contours (solid lines) at intervals of 100 geopotential feet. Dashed line is 10° C. dew point line. Barbs on wind shafts indicate speed in knots (full barb=10 knots). Numbers near station circles represent spread (in °C.) between the air temperature and the dew point. Blocked "X" shows positions of Low 12 hours before and after the present map position.

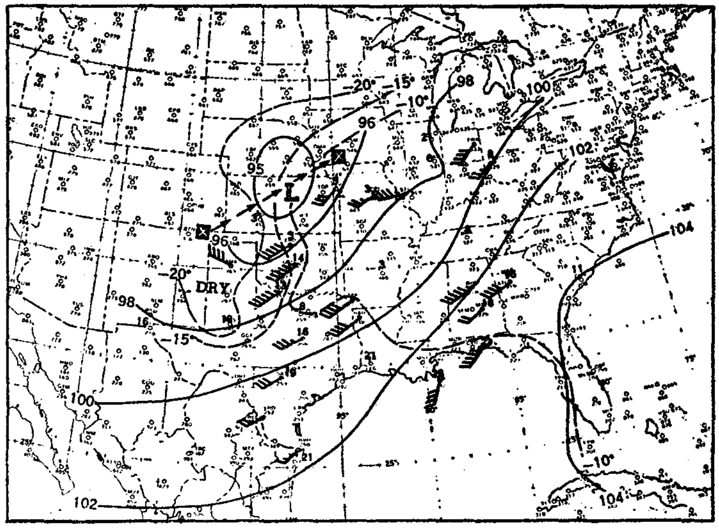

FIGURE 9.—700-mb. chart, 0300 GMT, March 22, 1952. Contours (solid lines) at intervals of 200 geopotential feet except 100 feet for contour line around Low. Selected lines of equal dew point at 5° C. intervals (dashed lines).

mb. level as can be seen by inspection of the wind reports and the gradient which show southerly winds in excess of 50 knots over northern Mississippi and western Tennessee. This area is approximately the region just east of the instability line (fig. 3).

Curve 1 of figure 11 (A) is a particularly clear cut example of a "pre-tornado" moisture distribution. The dotted curve (fig. 11 (B)) shows the temperature inversion which capped this low level moist layer. A comparison of curves 2, 3, and 4 of figure 11 (A) points out the changes in the moist layer from before the tornado outbreak to conditions following in its wake.

Even though the 700-mb. data are sparse in the vicinity of the instability line (fig. 9) it can be inferred that dry air preceded it. The temperature-dew point spread at Nashville and Dayton show drier air to the east of the line. From the reports at this level it is possible to note two facts, namely, the wind speed shear from 850 mb. to 700 mb. and the apparently strong advection of dry air indicated by the dew point lines and the wind flow over the western half of Oklahoma. The region of driest air is behind the surface, continental Polar cold front which produced tornadoes later on as mentioned elsewhere.

The band of strong southwest winds at the 700-mb. level is also evident at the 500-mb. level (fig. 10) but displaced more toward the west with the line of maximum winds located along a line from Oklahoma City, Okla., toward Columbia, Mo. This position, incidentally, just about coincides with the position of the 300-mb. jet stream axis, along which there is a band of winds having speeds of about 120 knots over a 60-mile wide strip just east of Tulsa which narrowed to a point at the intersection of the northwestern corner of Arkansas and the southwestern

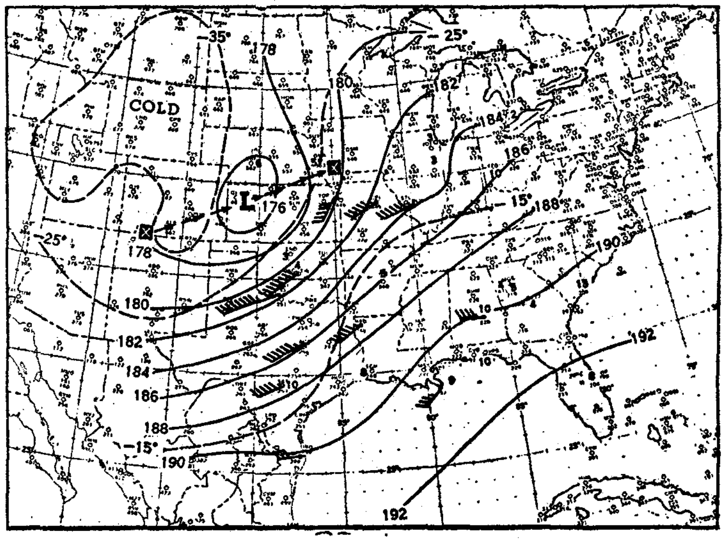

FIGURE 10.—500-mb. chart, 0300 GMT, March 22, 1952. Contours (solid lines) at intervals of 200 geopotential feet. Isotherms (dashed lines) for selected values at 5° C. intervals.

corner of Missouri. Winds at this level exceed 100 knots over a band extending from Little Rock to Wichita, Kans.

Returning to figure 10, the 500-mb. chart for 0300 GMT of the 22d, it can be seen that wind speeds over the tornado area increased sharply with height between 700 mb and 500 mb., but without change of direction. There is no strong cold advection at the 500-mb level in the region where tornadoes were occurring. Figures 8, 9, and 10 show that the contours aloft were straight when tornado conditions existed in western Tennessee and western Kentucky, but a comparison with previous charts shows that the contours were changing from less cyclonic to more cyclonic, indicating advection of cyclonic vorticity into that region.

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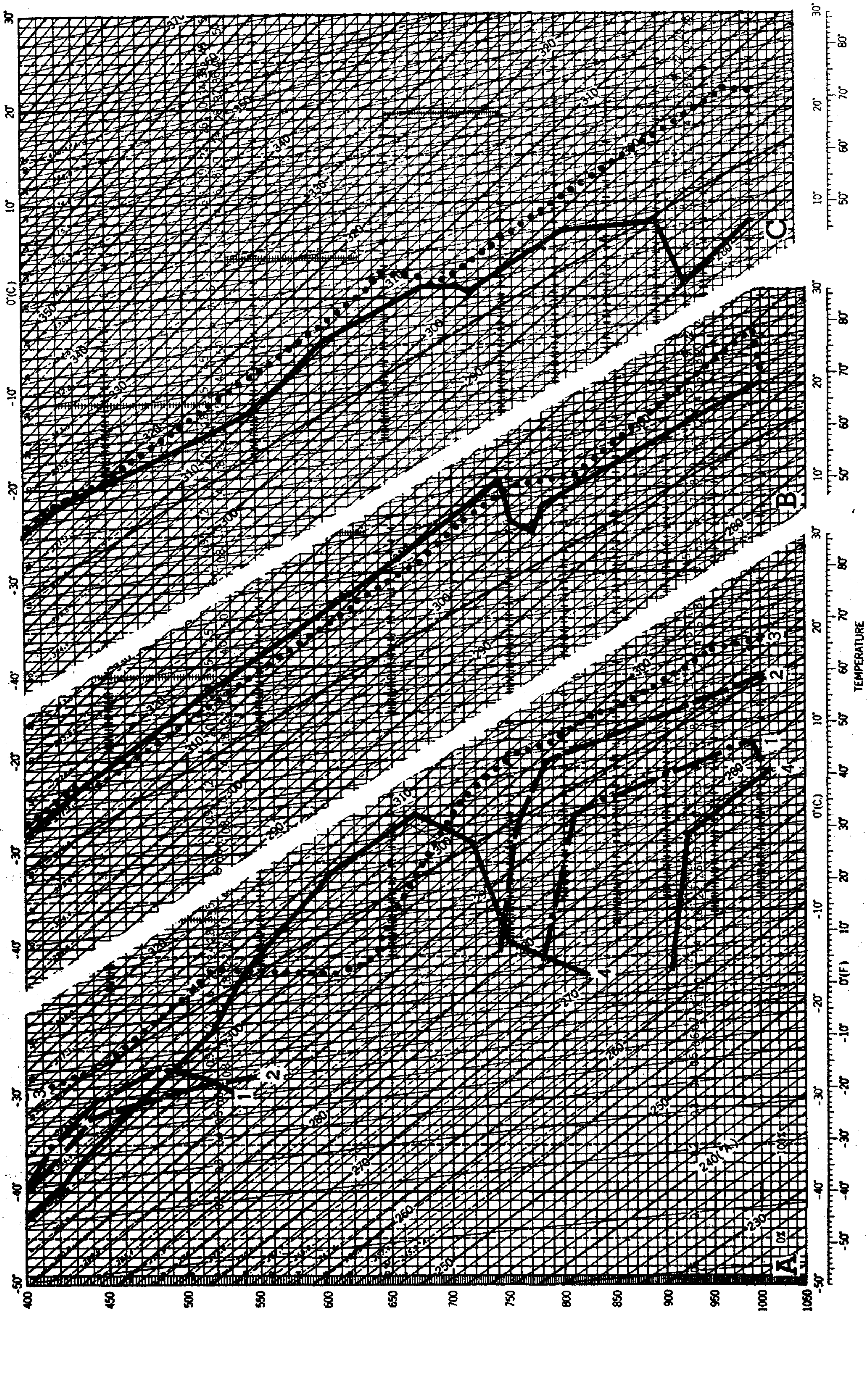

FIGURE 11.—(A) Dew point curves, Little Rock, Ark., March, 1952. Curve 1, 0300 GMT, (21st), curve 2, 1500 GMT (21st), curve 3, 0300 GMT (22d), and curve 4, 1500 GMT (22d). (B), (C) Temperature curves, Little Rock, Ark., March 21 and 22, 1952, respectively. Dotted curve, 0300 GMT; solid curve, 1500 GMT.

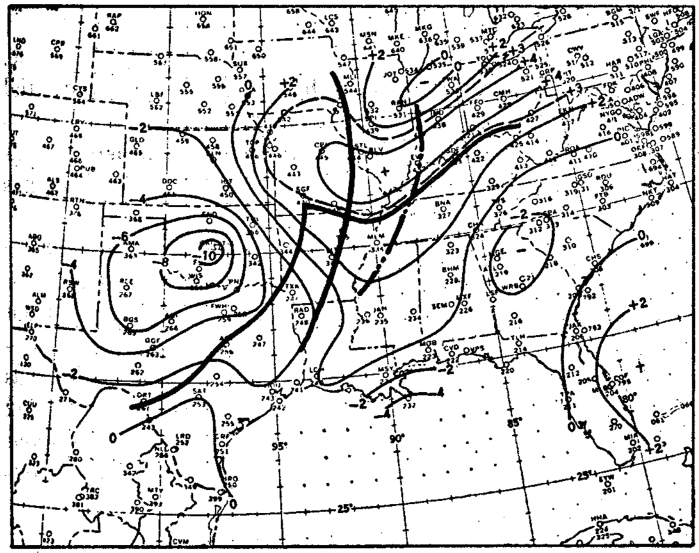

FIGURE 12.—850-mb. 12-hour temperature change chart, 1500 GMT March 21 to 0300 GMT March 22, 1952. Solid lines represent change at intervals of 2° C. Heavy solid lines show 0330 GMT surface frontal positions.

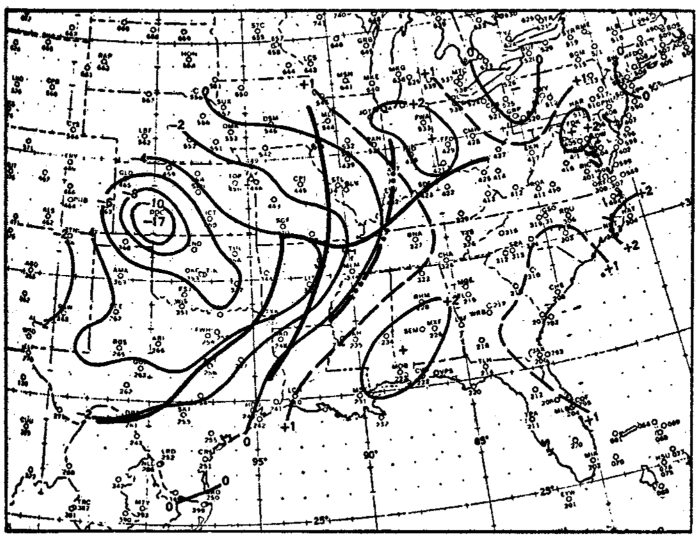

FIGURE 13.—700-mb. 12-hour temperature change chart, 1500 GMT March 21 to 0300 GMT on March 22, 1952.

The 12-hour temperature change charts, figures 12, 13, and 14 for the 850-, 700-, and 500-mb. levels respectively, show important changes in the stability of the air between 1500 GMT on the 21st and 0300 GMT on the 22d. It is significant that, within the area where tornadoes were occurring at the end of the 12-hour period, temperatures had increased at 850 mb. and had decreased at 700 mb. showing a decrease in the vertical stability.

Figures 12, 13, and 14 also illustrate the ineffectiveness of the maritime Polar front in producing tornadoes. In particular, figure 13 shows the strongest gradient of temperature change near the tornado zone and between the instability line and the maritime Polar front. In other words, with the passage of the instability line there was a marked change to cooler at 700 mb. over the major tornado area of Arkansas and Tennessee, but the arrival of

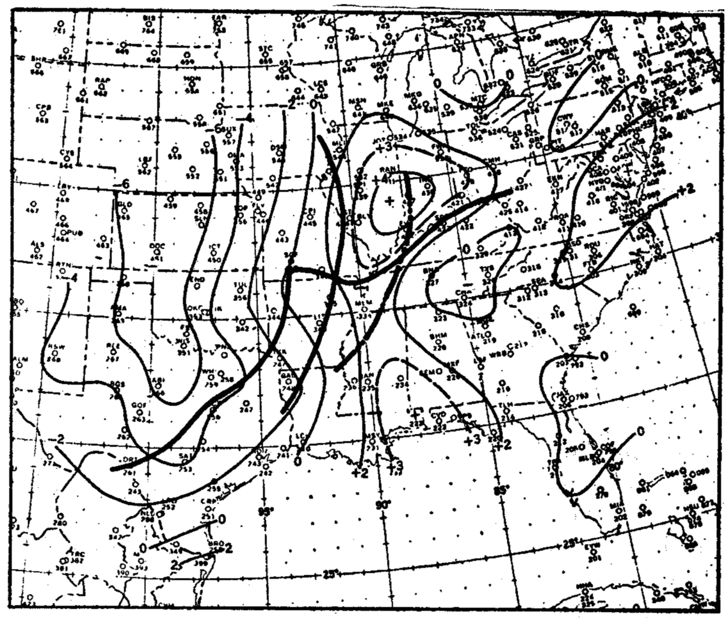

FIGURE 14.—500-mb. 12-hour temperature change chart, 1500 GMT March 21 to 0300 GMT on March 22, 1952.

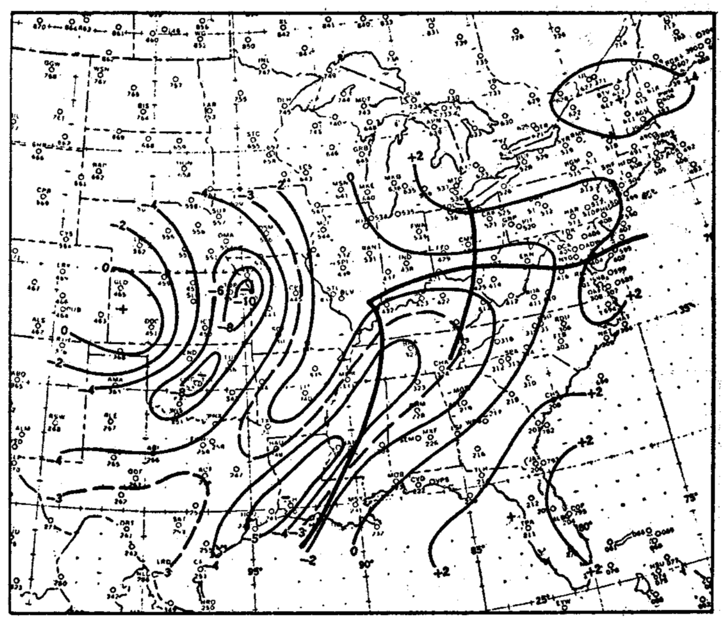

FIGURE 15.—700-mb. 12-hour temperature change chart, 0300 GMT March 22 to 1500 GMT on March 22, 1952. Heavy solid lines show 1530 GMT surface frontal positions.

the maritime Pacific front was not accompanied by further cooling at the 700-mb. level.

Figure 14 shows warming at the 500-mb. level over the same area which cooled at 700 mb. This warming could possibly be explained as the result of heat being carried upward from below by the intense convective activity.

Figure 15 shows the 700-mb., 12-hour temperature change in the period ending 1500 GMT of the 22d. An interesting feature of this chart is the off-shoot (for the most part west of the surface cold front) extending northeastward from Lake Charles, La. The bulging northeastward from the surface cold front over Mississippi to the vicinity of West Virginia can be ascribed to precipitational cooling and the cooling connected with the instability line at 700 mb., but this does not explain the cooling over Louisiana. However, this cell of cooling seems to be something which may be thought of as a wave of cold air surging out ahead of the main trough aloft. This condition is usually associated with instability line conditions. In this case, tornadoes occurred in Louisiana, Mississippi, and Alabama in connection with a cold frontal passage and the wave of pronounced cooling just mentioned.

METHODS OF INDICATING INSTABILITY

One method of indicating instability in connection with the forecasting of tornado occurrences is that described by Fawbush, Miller, and Starrett [1]. It consists of charting the horizontal variation of the level of free convection (LFC) in the maritime tropical air, a pressure of 650 mb. or greater being taken as a necessary (but not sufficient) condition for the occurrence of tornadoes. Figures 16, 17, and 18, the potential instability charts for 1500 GMT on the 21st and 0300 GMT and 1500 GMT on the 22d, show the LFC pattern and also the distribution of the mean values of mixing ratio within the lower moist layer of maritime tropical air.

Another means of representing the instability is a method credited in this country to Showalter (but not published) whereby an air parcel at 850 mb. is considered to move dry adiabatically to the condensation level and then along the saturation adiabat to the 500-mb. level where the computed temperature is subtracted algebraically from the observed temperature at that level to obtain a stability index. If the temperature of the lifted parcel is warmer than the observed temperature at 500 mb. the air is considered potentially unstable. Therefore, negative values of the index indicate potential instability. Figures 19, 20, and 21 illustrate the distribution and degree of instability as determined by this method for times corresponding to the times of figures 16, 17, and 18, respectively.

Figure 16 shows the distribution of moisture and the levels of free convection 5 hours, 20 minutes before the first reported tornado. At that time, the nearest front extended through the center of Oklahoma and its movement into the region of a 750-mb. LFC value which was around Little Rock, would not be expected for some 12 hours. But the development of an instability line about the time of the first tornado provided a "trigger" suf-

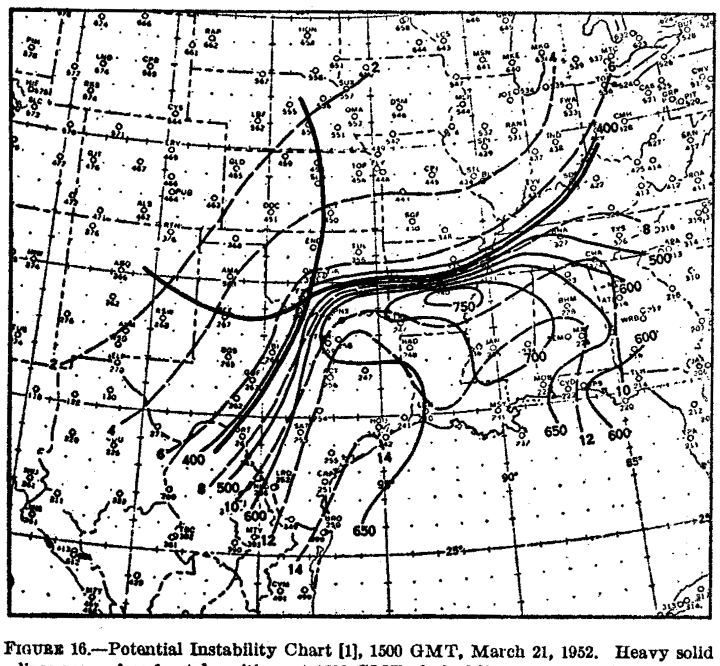

FIGURE 16.—Potential Instability Chart [1], 1500 GMT, March 21, 1952. Heavy solid lines are surface frontal positions at 1530 GMT; dashed lines connect points of equal mean mixing ratio (g./kg.) at 2-gram intervals. Lighter solid lines connect points of equal pressure of the free convection level (expressed in mb.).

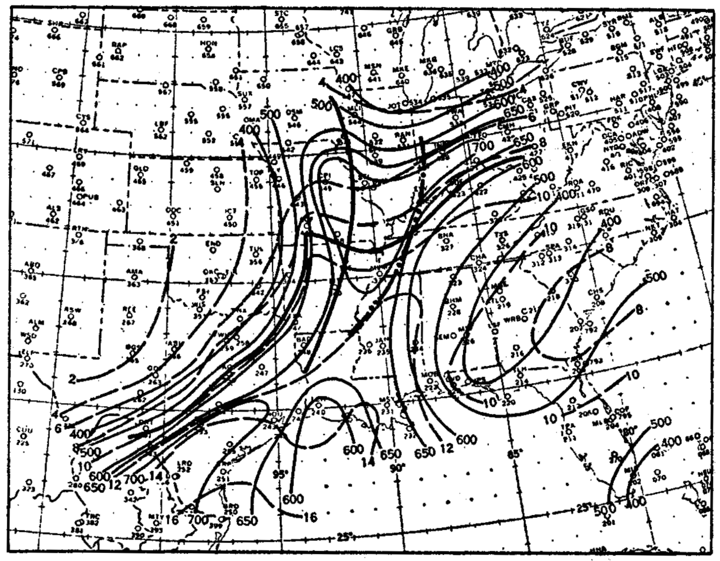

FIGURE 17.—Potential Instability Chart, 0300 GMT, March 22, 1952. Surface frontal positions at 0330 GMT.

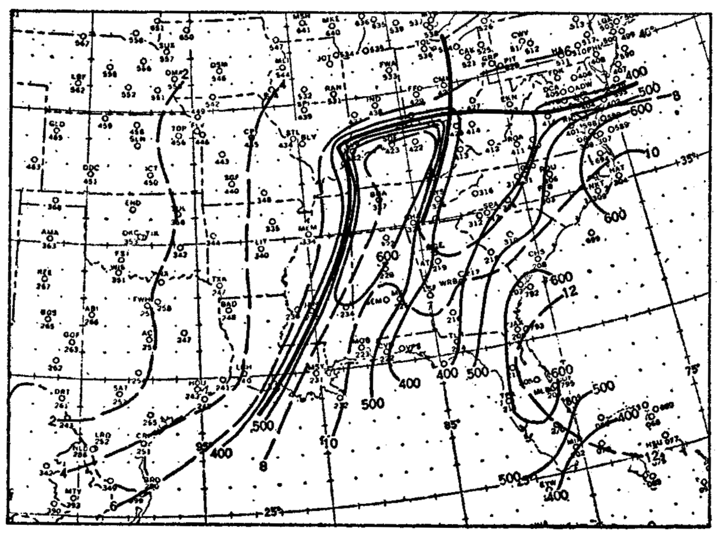

FIGURE 18.—Potential Instability Chart, 1500 GMT, March 22, 1952. Surface frontal positions at 1530 GMT.

ficient to produce tornadoes in the area of marked instability. Figures 4 and 16 taken together show that the instability line moved through the region where the LFC had highest pressures, that is, from the vicinity of Little Rock northeastward. The Showalter instability index chart, figure 19 (same time as figure 16), does not appear to be as definitive in this case as the LFC areas, but it does show a band of potential instability across the Gulf States from Georgia to east central Texas. The area of greatest negative values (−4°) is quite a bit south of the critical area of figure 16.

In figure 17, the axis of the greatest LFC values runs from Laredo, Tex., northeastward to Memphis and then northward. The region where tornadoes had been, or were, occurring was within the area of 650 to 700 mb. in western Tennessee. Figure 20, the Showalter instability index chart, shows the extension northward of large negative values toward the areas of tornadoes in Arkansas and Tennessee. Incidentally, the value at Lake Charles was −8°, but, lacking frontal or instability line activity in that area, such a high degree of instability was ineffective in producing tornadoes. Twelve hours later, the potential instability chart (fig. 18) and the Showalter instability index chart (fig. 21) showed marked changes. In figure 18, the lowest level of free convection had lifted to a value of 640 mb. at Nashville and the amount of moisture had decreased. The tornadoes occurred in Alabama (fig. 1) when the surface cold front moved into an area where the LFC was about 600 mb. Figure 21 also shows considerable weakening of the potential instability in 12 hours, with most of the land areas showing a stable or increasingly stable index, except Lake Charles where the value was −5°. There was still no activity in the vicinity of Lake Charles sufficient to produce tornadoes.

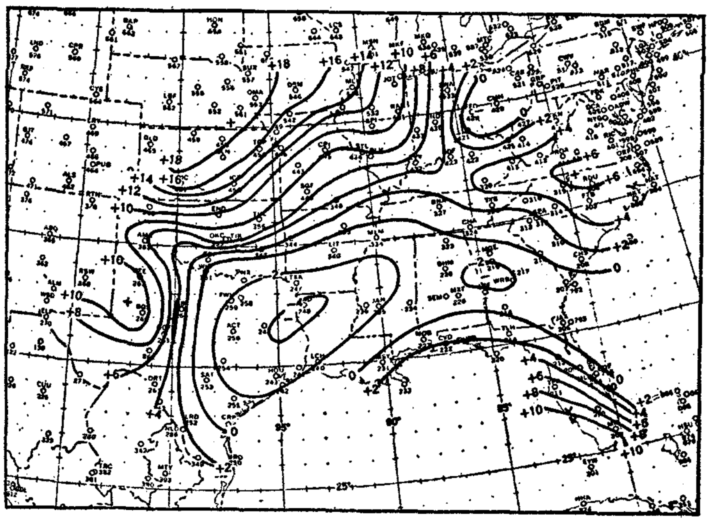

FIGURE 19.—Showalter Instability Index Chart, 1500 GMT, March 21, 1952. Isopleths (solid lines) of temperature difference at intervals of 2° C. Negative signs indicate instability.

PRESSURE CHANGES AT DYERSBURG, TENN., WITHIN TORNADO

Figure 22 is a reproduction of the barogram at Dyersburg, Tenn., March 21–23, showing the drop in pressure as a tornado passed over the barograph. The station, operated by the Civil Aeronautics Authority, is located at the airport on top of a hill. The average ground elevation of the airport is given as 334 feet above mean sea level, while the barograph is at a height of 337.75 feet.

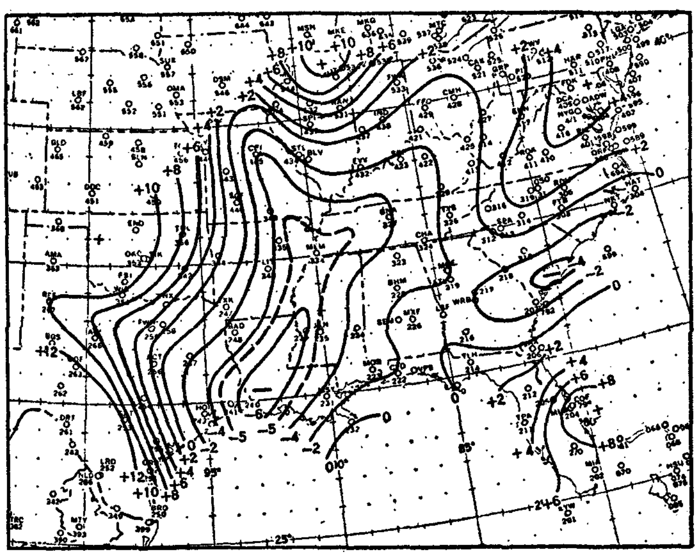

FIGURE 20.—Showalter Instability Index Chart, 0300 GMT, March 22, 1952.

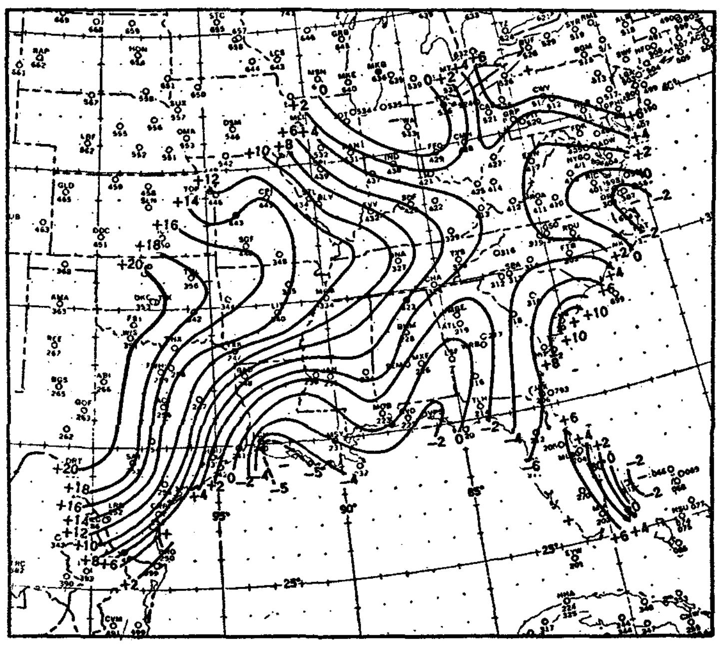

FIGURE 21.—Showalter Instability Index Chart, 1500 GMT, March 22, 1952.

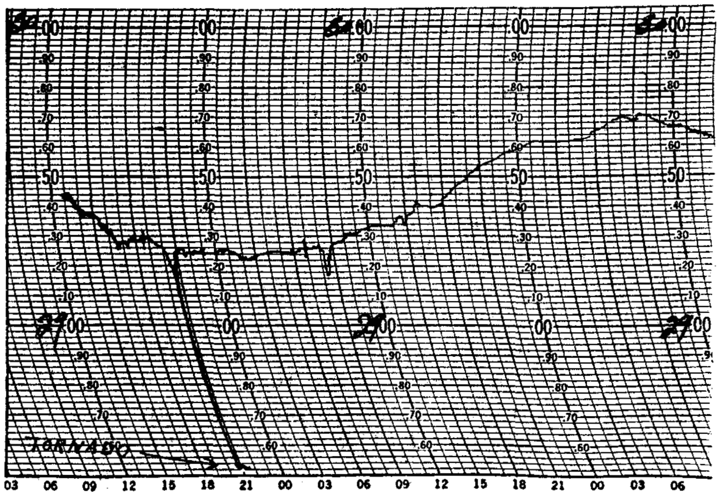

FIGURE 22.—Barogram trace made at Dyersburg, Tenn., March 21–23, 1952.

The center of the tornado (presumably taken as the middle of the path of destruction) passed 41 yards north of the barograph, and the barograph was 88 yards north of the south edge of the tornado as evidenced by destruction, according to information furnished by the Civil Aeronautics Authority. The destructive width of the tornado at that point was 258 yards. The decrease in pressure of approximately 0.65 inch with passage of the tornado, as shown on the trace, is perhaps somewhat less than the true drop because of probable lag in response of the instrument.

REFERENCE

1. E. J. Fawbush, R. C. Miller, and L. G. Starrett, "An Empirical Method of Forecasting Tornado Development", *Bulletin of the American Meteorological Society*, vol. 32, No. 1, January 1951, pp. 1–9.

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